HOLT CONSULTING ENGINEERS (PTY) LTD

TUMELA 18 TON SKIP DESIGN

H-MAX603

H-MAX603-CAL-MM-18SKIP-001-SHT-001

Engineer:	Gerald Holt (Pr.Eng)
Registration:	20020259
Email:	gerald@holtconsulting.co.za
Phone:	+27-791-2549
Adress:	Unit G, Mini Park
	16 Gerhardus Street, Strijdom Park
	Randburg, South Africa
Website:	www.holtconsulting.co.za

REVISION HISTORY

REV	DESCRIPTION	DATE	ISSUED BY	REVIEWED BY	APPROVED
A	ISSUED FOR REVIEW	2022-10-15	G.G. HOLT	H.F. HOLT	

1 CUSTOMER DETAILS

Customer:	Max Power Services (Pty) Ltd
Customer Name:	Herman de Koker
Customer Email:	harry@maxpower.co.za

2 CALCULATION INPUT DATA

2.1 Applicable Design Codes

SANS 10208: 3 - 2017: Design of structures for the mining industry Part 3: Conveyances

SANS 10610: Buildling loading code

SANS 10162: Steel design

2.2 General Data

Design Method	Limit States (Rope Break Conditions)	
Material of Construction	Main Body: EN10025 S355JR	
Material of Construction	Liners: VRN 500	
Yield Stress	355	MPa
Skip Weight	9878	kg
Payload	18000	kg
Winding Speed	15	m/s
Winding Rope Diameter	54	mm
Winding Rope Unit Mass	12.45	kg/m
Rope Break Force	2319	kN
Ultimate Tensile Strength	1900	MPa
Winder Acceleration	0.8	m/s^2
Winder Trip Acceleration	5	m/s^2
Winder Travel Distance	1023	m
Number of Cycles per Month	3000	
Skip Internal Height	5600	mm
Skip Internal Width	1557	mm
Skip Internal Depth	1400	mm
Skip Overall Height	10713	mm
Skip Overall Width	1856	mm
Skip Overall Depth	1743	mm
Ore Bulk Density	1950	kg/m^3

2.3 Assumption Data

Spacing between rails	1800	mm
Top Hat Guide Specification	340 x 175mm	
Top Hat Guide Material Specification	EN10025 S355JR	
Top Hat Guide Unit Mass	85.95	kg/m
Top Hat Guide Width	175	mm
Bunton Stiffness	1608000	N/m
Guide Stiffnes	1600000	N/m

2.4 Sketches and Drawings

2.4.1 General Arrangement

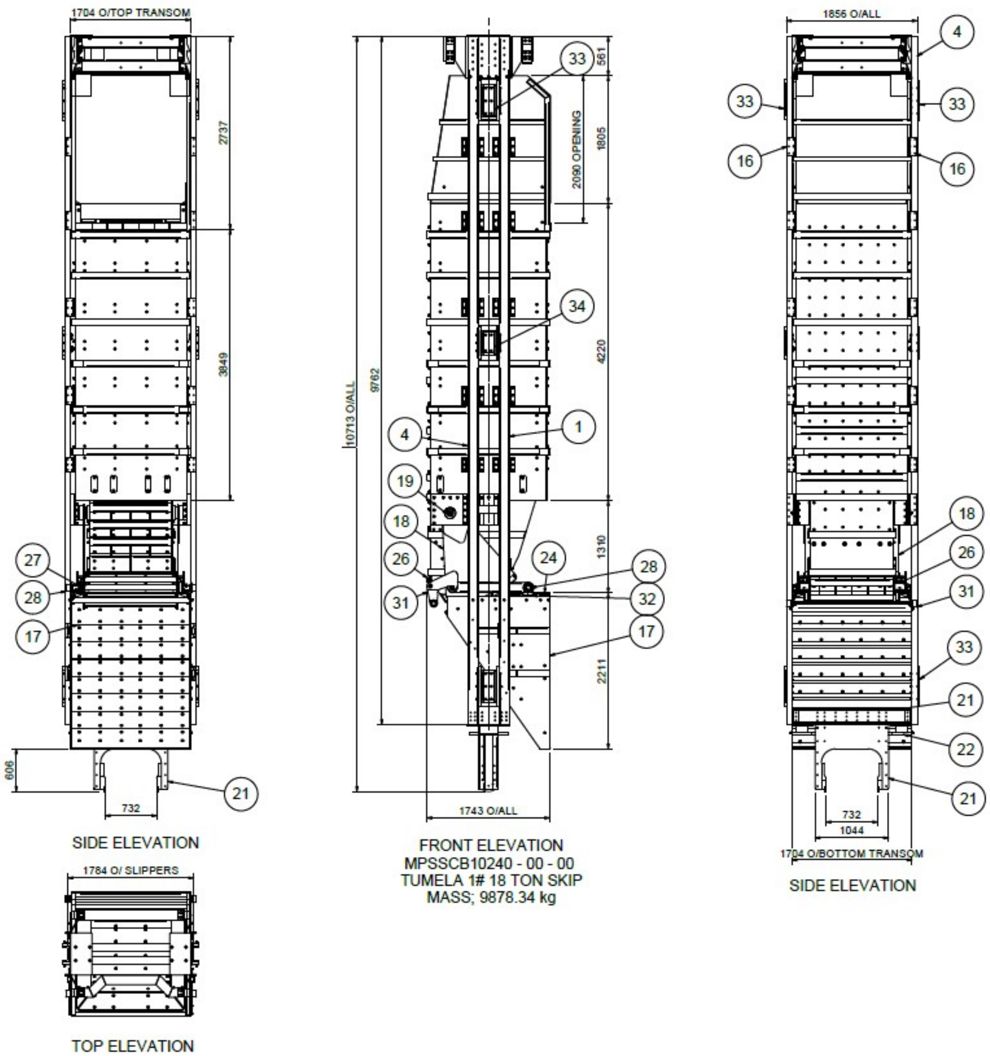
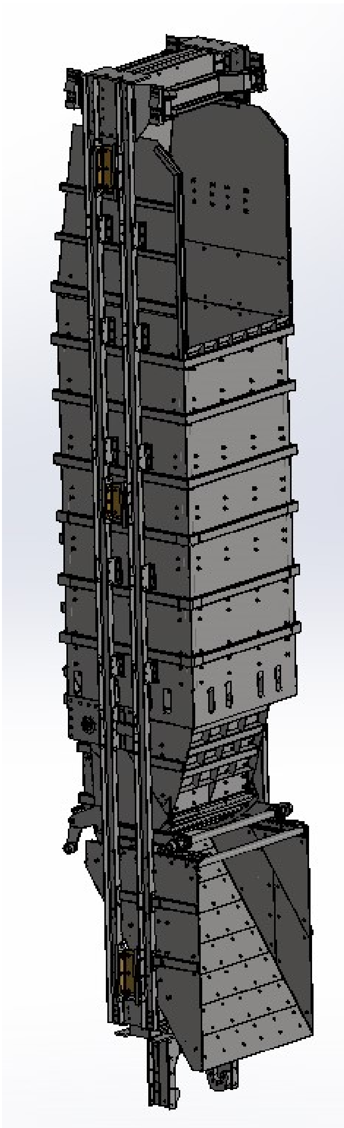
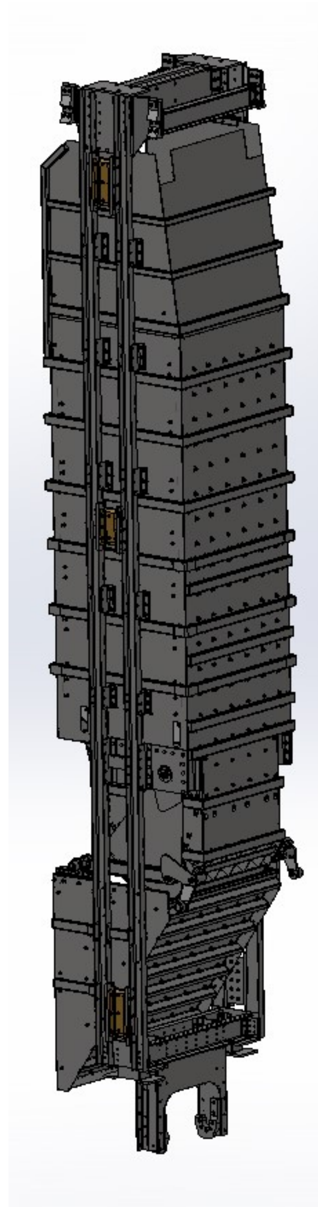


Figure 1: 18 ton Skip Drawing

2.4.2 Isometric Views



(a) 18 ton Skip Isometric View 1



(b) 18 ton Skip Isometric View 3

3 CALCULATIONS

3.1 Skip Loads

3.1.1 Basic Skip Parameters

Payload	R	18000	kg
Payload	R_l	176580.0	N
Winding Speed	V_w	15	m/s
Winder Acceleration	a_w	0.8	m/s^2
Winder Trip Acceleration	a_t	5	m/s^2
Winding Rope Diameter	$Rope_d$	54	m/s^2
Rope Break Force	RBF	2319	kN
Ultimate Tensile Strength	UTS	1900	MPa
Ore Bulk Density	ρ_b	1950	kg/m^3
Skip Internal Width	b	1557	mm
Skip Internal Depth	w	1557	mm
Skip Volume Required	$Vol = R/\rho_b$	9.2	m^3
Ore Height in Skip	$h = Vol/(bw)$	4.2	m
Rope Strentch Under Payload	ΔL	765.8	mm

3.1.2 Permanent Loads

Skip Bridle Sides	m_1	1167	kg
Skip Bridle Top Transom	m_2	1522	kg
Skip Bridle Bottom Transom	m_3	850	kg
Skip Unit	m_4	6336	kg
Permanent Load	$G_c = (m_1 + m_3 + m_4)g$	81943	N

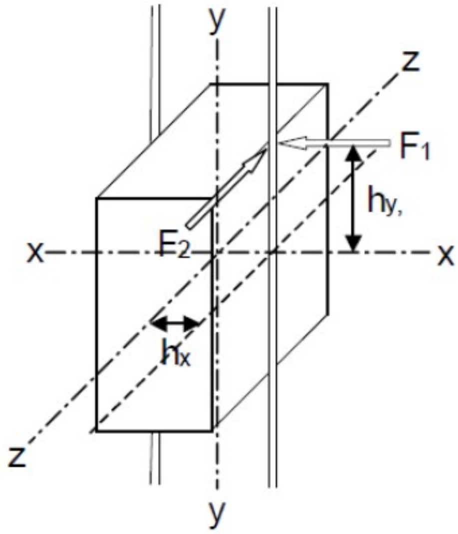


Figure 3: Properties Diagram

3.1.3 Laterial Imposed Loads (H) - Fixed Guide Systems in Vertical Shafts

Clearance between Roller and Slipper	Δ_c	10	mm
Slipper Plate Impact Factor	α_n	2	
Guide Roller Assembly Stiffness	k_r	500000	N/m
Bunton Stiffness	k_b	1608000	N/m
Guide Stiffnes	k_g	1600000	N/m
Moment of Inertia about X-axis	I_x	80510	$kg.m^2$
Moment of Inertia about Y-axis	I_y	6838	$kg.m^2$
Moment of Inertia about Z-axis	I_z	82050	$kg.m^2$
Distance from slipper to center of gravity	h_x	892	mm
Distance from slipper to center of gravity	h_y	4847	mm
Distance from slipper to center of gravity	h_z	28	mm
Guide Roller Lateral Load	H_f	5000000	N
Steelwork Stiffness Ratio	r_k	1.005	
Weight of Skip System	m_c	8353	kg
Effective Mass About y - x Plane	$m_x = (m_c I_z)/(I_z + m_c(h_y)^2)$	2463.0	kg
Effective Mass About y - z Plane	$m_z = (m_c I_x I_y)/(I_x I_y + (m_c I_x(h_y)^2) + (m_c I_y(h_x)^2)$	280.0	kg
Non-Dimensional Laterial Stiffness	$K_x = (k_b L_b^2)/m_x V^2$	9	
Non-Dimensional Laterial Stiffness	$K_z = (k_b L_b^2)/m_z V^2$	83	
Plate Coefficient from graph	P_b	0.05	
Maximum Moving Misalighnment	e	0.01	m
Lateral Slipper Pad Load	H_s	7791	N

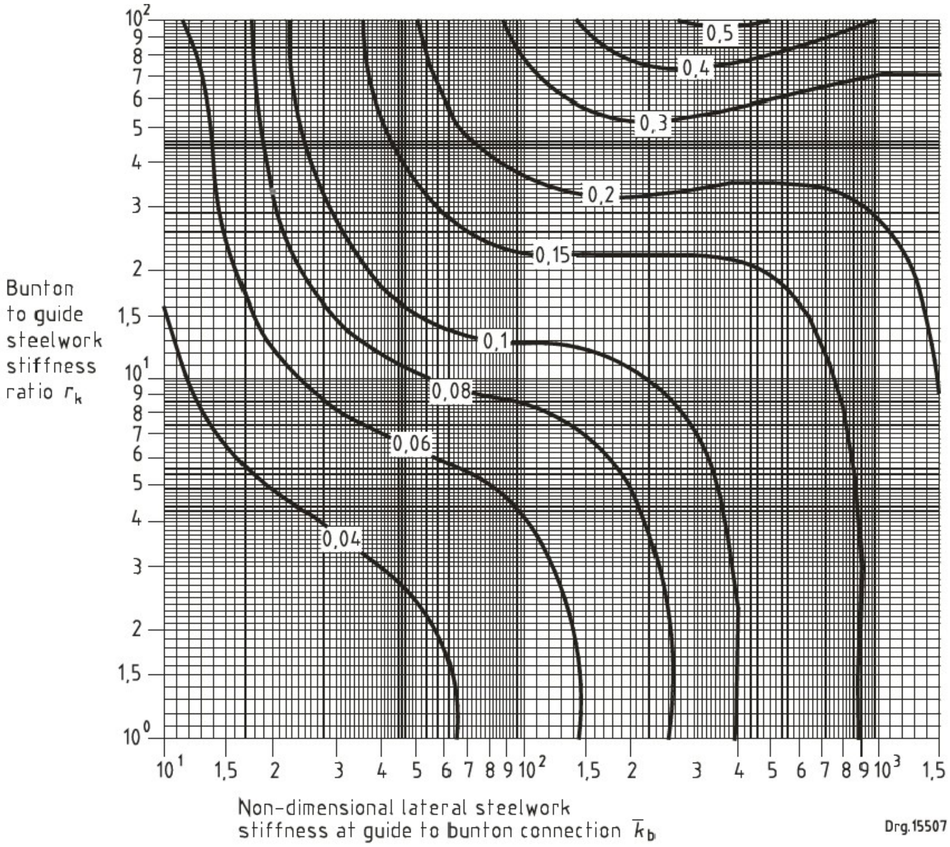


Figure 1 — Contour plot of slipper plate load coefficient $\overline{P_b}$

Figure 4: Slipper Plate Load Coefficient Pb

3.1.4 Winder System Loads

Dynamic Impact Factor	α_d	2	
Winder Acceleration and Deceleration	a_o	0.8	m/s^2
Winder Trip Acceleration	a_t	0.8	m/s^2
Skip Self Weight	G_c	81943	N
Content Load	C_y	176580.0	N
Tail Rope Load	T	0	N
Acceleration Load	$A_o = (\alpha_d)a_o(G_c + C_y + T)/g$	42165	N
Acceleration Trip Out Load	$A_t = (\alpha_d)a_t(G_c + C_y + T)/g$	263530	N

3.1.5 Emergency Loads

Emergency Load	E_r	2319000	N

3.1.6 Vertical Friction Loads

Lateral Slipper Pad Load	H_s	7791	N
Vertical Friction Load	$F_v = 0.5H_s$	3895.5	N

3.1.7 Rock Loads

Filling Impact Factor in Stationary Position	α_v	1.5	
Load on Tipping Rollers Impact Factor	α_t	2	
Static Load	R	176580.0	N
Bridle Transom Load While Filling	$R_d = (\alpha_v)(R)$	27000.0	N
Rock Pressure	$p_o = \rho_b g h$	80.3439	N/m^2
Pressure on the Door	$p_1 = 1p_o$	80.3	N/m^2
Pressure on the Back of Skip	$p_2 = 0.5p_o$	40.2	N/m^2
Pressure on the Lower Portion Skip Back	$p_3 = 0.5p_o$	120.5	N/m^2
Pressure on the Front and Sides of Skip	$p_4 = 0.2p_o$	16.1	N/m^2

3.2 Skip Element Design

3.2.1 Top Transom

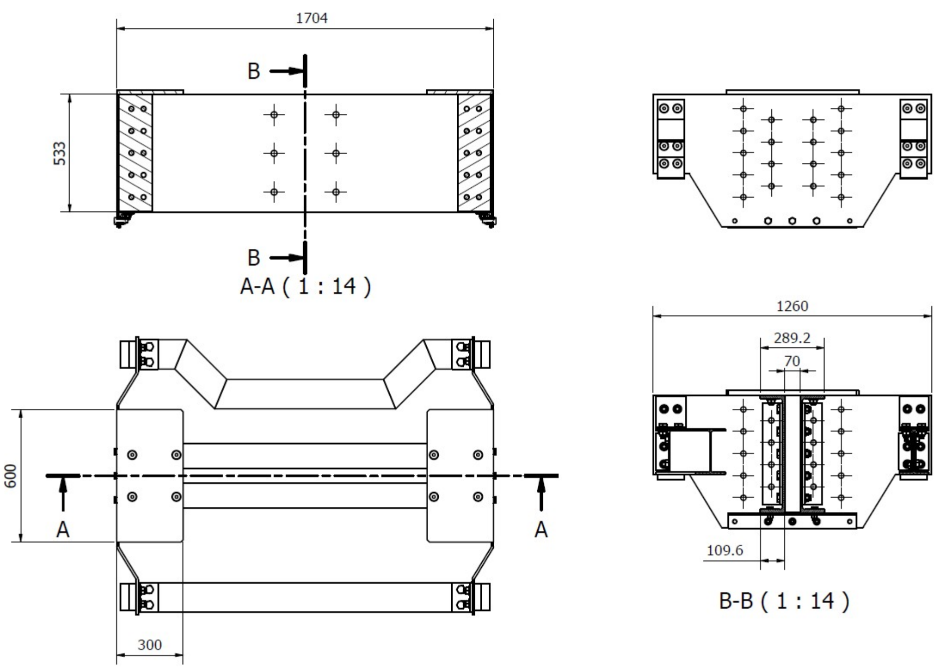


Figure 5: Top Transom Configuration

Material Data

2 / 533 x 110 CHANNEL (MODIFIED 533 X 210 X 93 UB) WITH TOP AND BOTTOM 20 X 100 PLATE

4 / 20 X 100 PLATES (TOP AND BOTTOM)

2 / 150 x 150 ANGLE END CONNECTIONS

Length of Transom	L	1700	mm
Channel Width	b	109	mm
Channel Height	h	533	mm
Channel Web Thickness	t_w	10.2	mm
Channel Flange Thickness	t_f	15.6	mm
Top and Bottom Plate Width	w	110	mm
Top and Bottom Plate Thickness	t_p	20	mm
Yield Stress	f_y	355	MPa
Channel Cross Sectional Area	$A = 2bt_f + h_w * t_w$	8519.0	mm^2
Channel Centroid Distance	$x_c = (0.5h_w t_w^2 + t_f b^2)/A$	25.0	mm
Channel Second Moment of Area about x-x	$I_x = bh^3/12 - b_f h_w^3/12$	335071491.0	mm^4
Channel Second Moment of Area about y-y	$I_y = h_w t_w^3/3 + 2t_f b^3/3 - Ax_c^2)$	8397644.0	mm^4
Double Plate Polar Moment	$J = I_x + I_y$	340973234.0	mm^4
Channel Warping Constant	$C_w = (1/144)(t_f^3 b^3) + (1/36)(h - t_f/2)^3)t_w^3$	4304577645.0	mm^6
Channel Plastic Section Modulus	$Z_p = bh^2/4 - b_f h_w^2/4$	1521885.0	mm^3
Double Plate Cross Sectional Area	$A = 2(wt_p)$	4400	mm^2
Double Plate Second Moment of Area about x-x	$I_x = w/12(H^3 - h^3)$	336536567.0	mm^4
Double Plate Second Moment of Area about y-y	$I_y = t_p w^3/6$	4436667.0	mm^4
Double Plate Plastic Section Modulus	$Z_p = 2(wt_p(h - t_p/2)$	2301200.0	mm^3
Combined Second Moment of Area about x-x	I_x	671608058.0	mm^3
Combined Second Moment of Area about y-y	I_y	12834311.0	mm^3
Combined Plastic Section Modulus	Z_p	3823085.0	mm^3
Plastic Moment	$M_p = Z_p f_y$	1357.2	kNm
Adjusted Plastic Moment	$0.67M_p$	909.3	kNm
Critical Elastic Moment	$M_c = ((\pi^4 E^2 C_w I_y)/L^4 + (\pi^2 EI_y GJ)/L^2)^0.5$	20494.3	kNm
Factored Moment Resistance	$M_r = 1.15\phi M_p(1 - (0.28M_p/M_c))$	1378.7	kNm
Factored Shear Resistance	$Vr = 0.55\phi Af_y$	2270.0	kNm

Design for Emergency Loads

Rope Break Force	RBF	2319	kN
Number of Beams	$No.$	2	
Combined Shear Resistance	M_r	4540.0	kN
Ultimate Bending Moment	$M_u = RBFL/4$	986.0	kN
Ultimate Shear Force	$M_u = RBF/2$	1160.0	kN
Interaction Check	$M_u/M_r + V_u/V_r < 1$	0.61	$Pass$

Design for Operation Loads

Operation Force	$LC = 1.2G_c + 1.6R$	127.0	kN
Number of Beams	$No.$	2	
Combined Shear Resistance	M_r	4540.0	kN
Ultimate Bending Moment	$M_u = (RBF)L/4$	54.0	kN
Ultimate Shear Force	$M_u = (RBF)/2$	64.0	kN
Interaction Check	$M_u/M_r + V_u/V_r < 1$	0.03	$Pass$

Design for Fatigue Loads

Cycles per Month	$Cycles$	3000	
Design Life	$Design$	24	$months$
Total Number of Trips	$Trips$	72000	
Rock during Filling	$R_d = (\alpha_v)(R)$	27000.0	N
Permanent Load	$G_c = (m_1 + m_3 + m_4)g$	81943	N
Major Cycle Load	$MCL = R_d + 0.25G_c$	47485.75	N
Stress Amplitude	$\sigma_a = 0.5(MCL)L/(4Z_p))$	2.65	MPa
Acceleration Cycles Load	$2A_o$	84330	N
Stress Acceleration Increase	$\sigma_b = 0.5(2A_oL/(4Z_p))$	9.4	MPa
Bounding Load	$0.2R$	3600.0	N
Stress Acceleration Increase	$\sigma_c = 0.5(0.2RL/(4Z_p))$	0.4	MPa
Steel Endurance Limit	S_e	70	MPa
Interaction Check	$\sigma_a/S_e + \sigma_b/S_e + \sigma_c/S_e < 1$	0.11	$Pass$

3.2.2 Bottom Transom

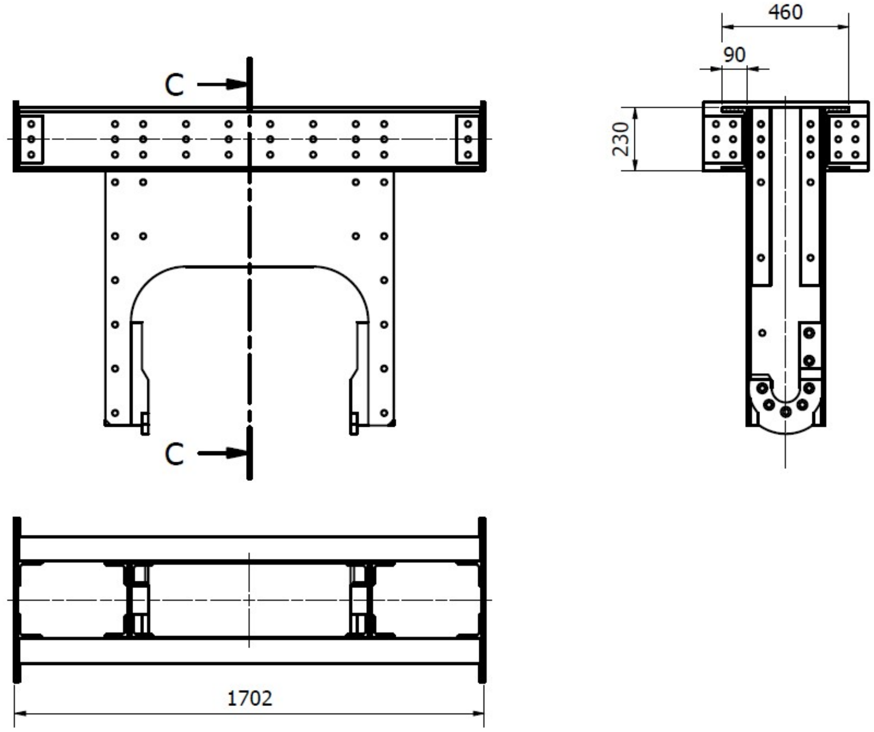


Figure 6: Bottom Transom Configuration

Material Data

2 / 230 x 90 CHANNEL

4 / 20 X 230 PLATES (TOP AND BOTTOM)

2 / 100 x 100 ANGLE END CONNECTIONS

Length of Transom	L	1700	mm
Channel Width	b	90	mm
Channel Height	h	230	mm
Channel Web Thickness	t_w	7.5	mm
Channel Flange Thickness	t_f	14	mm
Top and Bottom Plate Width	w	230	mm
Top and Bottom Plate Thickness	t_p	20	mm
Yield Stress	f_y	355	MPa
Channel Cross Sectional Area	$A = 2bt_f + h_w * t_w$	4035.0	mm^2
Channel Centroid Distance	$x_c = (0.5h_w t_w^2 + t_f b^2)/A$	30.0	mm
Channel Second Moment of Area about x-x	$I_x = bh^3/12 - b_f h_w^3/12$	34585945.0	mm^4
Channel Second Moment of Area about y-y	$I_y = h_w t_w^3/3 + 2t_f b^3/3 - Ax_c^2)$	3318071.0	mm^4
Double Plate Polar Moment	$J = I_x + I_y$	184613334.0	mm^4
Channel Warping Constant	$C_w = (1/144)(t_f^3 b^3) + (1/36)(h - t_f/2)^3)t_w^3$	143847363.0	mm^6
Channel Plastic Section Modulus	$Z_p = bh^2/4 - b_f h_w^2/4$	348668.0	mm^3
Double Plate Cross Sectional Area	$A = 2(wt_p)$	9200	mm^2
Double Plate Second Moment of Area about x-x	$I_x = w/12(H^3 - h^3)$	144056667.0	mm^4
Double Plate Second Moment of Area about y-y	$I_y = t_p w^3/6$	40556667.0	mm^4
Double Plate Plastic Section Modulus	$Z_p = 2(wt_p(h - t_p/2)$	2024000.0	mm^3
Combined Second Moment of Area about x-x	I_x	178642612.0	mm^3
Combined Second Moment of Area about y-y	I_y	43874738.0	mm^3
Combined Plastic Section Modulus	Z_p	2372668.0	mm^3
Plastic Moment	$M_p = Z_p f_y$	842.3	kNm
Adjusted Plastic Moment	$0.67M_p$	564.3	kNm
Critical Elastic Moment	$M_c = ((\pi^4 E^2 C_w I_y)/L^4 + (\pi^2 EI_y GJ)/L^2)^0.5$	21605.1	kNm
Factored Moment Resistance	$M_r = 1.15\phi M_p(1 - (0.28M_p/M_c))$	862.3	kNm
Factored Shear Resistance	$Vr = 0.55\phi Af_y$	2326.0	kNm

Design for Emergency Loads

Rope Break Force	RBF	2319	kN
Number of Beams	$No.$	2	
Combined Shear Resistance	M_r	4652.0	kN
Ultimate Bending Moment	$M_u = RBFL/4$	986.0	kN
Ultimate Shear Force	$M_u = RBF/2$	1160.0	kN
Interaction Check	$M_u/M_r + V_u/V_r < 1$	0.82	$Pass$

3.2.3 Bridle Hangers

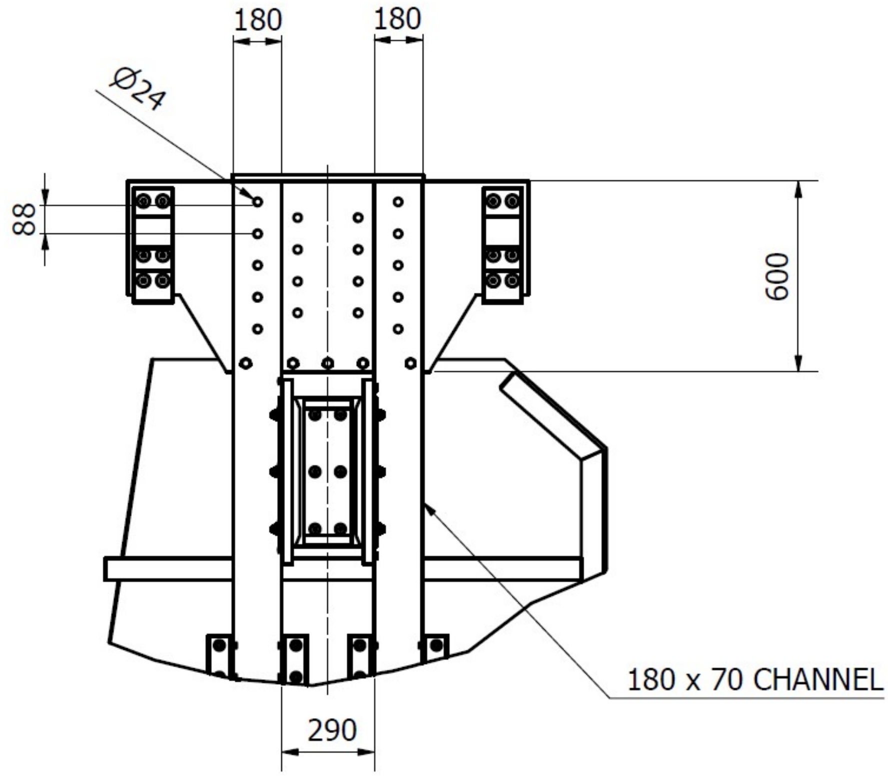


Figure 7: Bridle Configuration

Design for Emergency Loads

Total Cross Sectional Bridle Area	A_t	10720	mm^2
Total Net Cross Sectional Bridle Area	A_e	10048	mm
Rope Break Force	RBF	2319	kN
Tensile Resistance per Channel	$T_r = 0.85\phi A f_y$	682.0	N
Number of Bridless	$No.$	4	
Total Tensile Resistance	T_r	2728.0	N
Interaction Check	$T_u/T_r < 1$	0.85	$Pass$

Design for Fatigue Loads

Cycles per Month	$Cycles$	3000	
Design Life	$Design$	24	$months$
Total Number of Trips	$Trips$	72000	
Number of Bridle Channels	N_b	4	
Rock during Filling	$R_d = (\alpha_v)(R)$	27000.0	N
Permanent Load	$G_c = (m_1 + m_3 + m_4)g$	81943	N
Major Cycle Load	$MCL = R_d + 0.25G_c$	47485.75	N
Stress Amplitude	$\sigma_a = MCL/(N_b A_n))$	18.9	MPa
Acceleration Cycles Load	$2A_o$	84330	N
Stress Acceleration Increase	$\sigma_b = (2A_o/(N_b A_n))$	8.4	MPa
Bounding Load	$0.2R$	3600.0	N
Stress Acceleration Increase	$\sigma_c = (0.2R/(N_b A_n))$	0.4	MPa
Steel Endurance Limit	S_e	70	MPa
Interaction Check	$\sigma_a/S_e + \sigma_b/S_e + \sigma_c/S_e < 1$	0.4	$Pass$

4 SUMMARY

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